

# Disabling CNT Electronic Devices by Use of Electron Beams

Selected CNTs would be burned out.

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Bombardment with tightly focused electron beams has been suggested as a means of electrically disabling selected individual carbon-nanotubes (CNTs) in electronic devices. Evidence in support of the suggestion was obtained in an experiment in which a CNT field-effect transistor was disabled (see figure) by focusing a 1-keV electron beam on a CNT that served as the active channel of a field-effect transistor (FET).

Such bombardment could be useful in the manufacture of nonvolatile-mem-

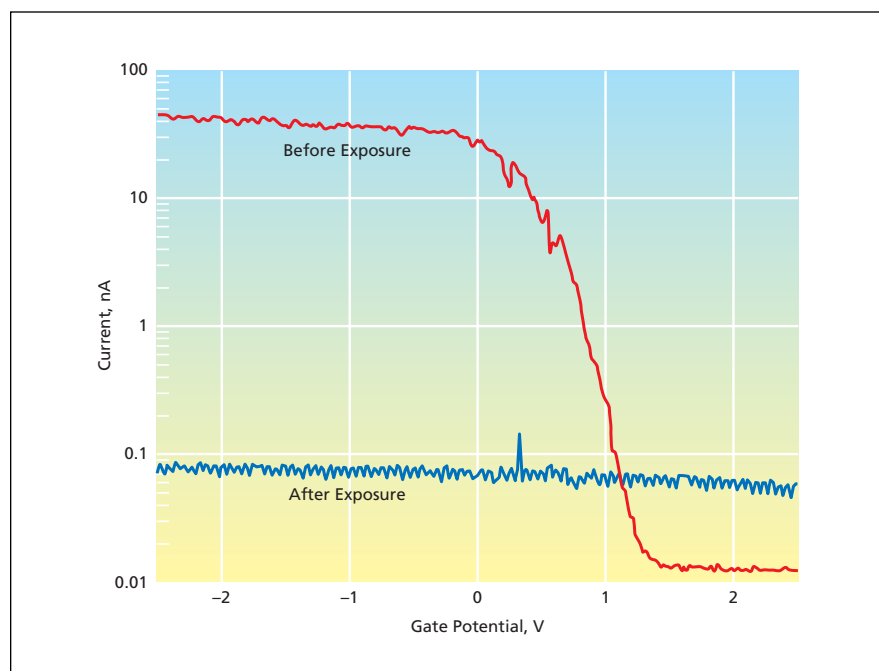
ory circuits containing CNT FETs. Ultimately, in order to obtain the best electronic performances in CNT FETs and other electronic devices, it will be necessary to fabricate the devices such that each one contains only a single CNT as an active element. At present, this is difficult because there is no way to grow a single CNT at a specific location and with a specific orientation. Instead, the common practice is to build CNTs into electronic devices by relying on spatial distribution to bridge contacts. This

practice results in some devices containing no CNTs and some devices containing more than one CNT. Thus, CNT FETs have statistically distributed electronic characteristics (including switching voltages, gains, and mixtures of metallic and semiconducting CNTs).

According to the suggestion, by using a 1-keV electron beam (e.g., a beam from a scanning electron microscope), a particular nanotube could be rendered electrically dysfunctional. This procedure could be repeated as many times as necessary on different CNTs in a device until all of the excess CNTs in the device had been disabled, leaving only one CNT as an active element (e.g., as FET channel).

The physical mechanism through which a CNT becomes electrically disabled is not yet understood. On one hand, data in the literature show that electron kinetic energy  $>86$  keV is needed to cause displacement damage in a CNT. On the other hand, inasmuch as a 1-keV beam focused on a small spot (typically a few tens of nanometers wide) deposits a significant amount of energy in a small volume, the energy density may suffice to thermally induce structural and/or electronic changes that disable the CNT. Research may be warranted to investigate this effect in detail.

*This work was done by Mihail Petkov of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).  
NPO-41343*



The Functionality of a CNT FET was destroyed by exposure to a focused 1-keV electron beam.